199. THERMAL BURNS - Lawrence R. Schwartz, Chenicheri Balakrishnan

INCIDENCE

The American Burn Association estimates there are more than 1 million burn injuries each year in the United States, generating about 700,000 ED visits and 45,000 hospitalizations.[1] Thus, the majority of burn patients are treated and discharged from the ED to be followed as outpatients. Approximately half of those hospitalized are admitted to the 125 specialized burn treatment centers, and the others are cared for in community hospitals. Fire and burn deaths account for about 4500 deaths each year.[1]

The risk of burns is highest in the 18- to 35-year-old age group. There is a male to female ratio of 2:1 for both injury and death. There is a higher incidence of scalds from hot liquids in children 1 to 5 years of age and in the elderly. The death rate in patients over 65 years of age is much higher than that in the overall burn population.[2,3]

Significant strides have been made in the overall care of the burn patient during the last two decades.[4,5] These advances are reflected in a decreased mortality rate among patients with major thermal injury; only about 4 percent of those treated in specialized burn treatment centers die from their injuries or associated complications.[6] The incidence of inpatient admissions has decreased over time owing to improvements in outpatient care both in the ED and in the burn unit. Currently, the risk of death from a major burn is associated with increased burn size, increased age, the presence of inhalation injury, and female sex.[3]

PATHOPHYSIOLOGY

Skin consists of two layers: the epidermis and the dermis. In the very young and the elderly, the skin thickness is less than that of a person in the prime of life. Skin thickness also varies significantly throughout the body. The skin is very thick in the palm of the hand and the sole of the foot. The skin on the upper part of the back is thicker than that of other parts of the body. Thus exposure to the same temperature for the same duration will lead to different depths of injury in different parts of the body.

Skin functions as a semipermeable barrier to evaporative water loss. Other functions of the skin include protection from the adversities of the environment, control of body temperature, sensation, and excretion. Partial-thickness thermal injury can result in disruption of the barrier function and contribute to free water deficits. The effect may be significant in moderate to large burns.

Thermal injury results in a spectrum of local and systemic homeostatic derangements that contribute to burn shock. These include disruption of normal cell membrane function, hormonal alterations, changes in tissue acid-base balance, hemodynamic changes, and hematologic derangement.

Fluid and electrolyte abnormalities seen in burn shock are largely the result of alterations of cell membrane potentials with intracellular influx of water and sodium and extracellular migration of potassium secondary to dysfunction of the sodium pump. In burns of greater than 60 percent of body surface area, depression of cardiac output is frequently observed with lack of response to aggressive volume resuscitation. Although disputed by others, Baxter and Shires[7] have explained this phenomenon on the basis of circulating myocardial depressants. Also, there is increased systemic vascular resistance. A significant metabolic acidosis may be present in early stages of a large burn injury.

Hematologic derangements associated with massive thermal injury consist of an increase in hematocrit with increased blood viscosity during the early phase, followed by anemia from erythrocyte extravasation and destruction. However, transfusion is not often required for patients with isolated burn injury.

Thermal injury is a progressive injury. Local effects of thermal injury include liberation of vasoactive substances, disruption of cellular function, and edema formation. The systemic response consists of responses by the neurohormonal axis and profound alterations of all organ systems. Substances implicated in these events are histamine, kinin, serotonin, arachidonic acid metabolites, and free oxygen radicals. These substances exert their primary effects at the local level and cause progression of the burn wound. Preservation of the blood supply by decreasing the inflammatory response has been attempted with pharmacologic manipulations using drugs such as nonsteroidal anti-inflammatories.[4,5]

Although many factors may influence prognosis, the severity of the burn, presence of inhalation injury, associated injuries, the patient's age, preexisting disease, and acute organ system failure are most important.[2,3] The burn's size and depth are functions of the burning agent, its temperature, and the duration of exposure. Cell damage occurs at a temperature greater than 45°C (113°F) owing to denaturation of cellular protein. The burn wound is described as having three zones: the zone of coagulation, where tissue is irreversibly destroyed with thrombosis of blood vessels; the zone of stasis, where there is stagnation of the microcirculation; and the zone of hyperemia, where there is increased blood flow. The zone of stasis can become progressively more hypoxemic and ischemic if resuscitation is not adequate. In the zone of hyperemia, there is minimal damage to the cells and spontaneous recovery is likely.

CLINICAL FEATURES

Burn Size

The size of a burn injury is quantified as the percentage of body surface area (BSA) involved.[5] One method of calculating the percentage of BSA burned is to use the Rule of Nines (Figure 199-1). This method divides the body into segments that are approximately 9 percent or multiples of 9 percent, with the perineum forming the remaining 1 percent. In infants and children, this method must be modified because of their larger heads and smaller legs.

Another method is based on the fact that the area of the back of a patient's hand is approximately 1 percent BSA. The number of "hands" that equal the area of the burn can approximate the percentage of BSA burned.

A more precise estimation of the percentage of BSA burned is obtained by using a Lund and Browder burn diagram (Figure 199-2). This allows for accurate determination of the size and depth. These charts are age-adjusted, which allows for changes in children at different ages as they grow.

Experienced burn-care nurses and physicians are reliable in estimating burn size regardless of the method used. However, it is common for inexperienced individuals to estimate burn size incorrectly when patients are first assessed in the ED.

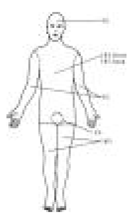

FIGURE 199-1. Rule of Nines to estimate percentage of burn.

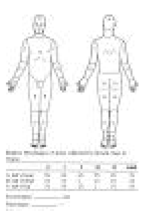

FIGURE 199-2. Lund and Browder diagram to estimate percentage of pediatric burn.

Burn Depth

The depth of a burn has historically been described in degrees: first, second, and third. However, a classification of burn depth according to the need for surgical intervention has become the accepted approach in burn treatment centers: superficial partial-thickness, deep partial-thickness, and full-thickness burns.[4] Determination of burn depth requires judgment, using commonly seen clinical features. There is no objective method of measuring burn depth, and burn wound biopsy has not become routine practice.

A first-degree burn involves only the epidermal layer of skin. Sunburn is usually given as a common example of a first-degree burn, although sunburn is caused by ultraviolet light instead of thermal injury.[8] The burned skin is red, painful, and tender without blister formation. First-degree burns usually heal in about 7 days without scarring and require only symptomatic treatment.

Second-degree burns extend into the dermis and are divided into superficial partial-thickness and deep partial-thickness burns.

In superficial partial-thickness burns, the epidermis and the superficial (papillary layer) dermis are injured. The deeper layers of the dermis, hair follicles, and sweat and sebaceous glands are spared. Superficial partial-thickness burns are often caused by hot water. There is blistering of the skin and the exposed dermis is red and moist at the blister's base. These burns are very painful to touch. There is good perfusion of the dermis with intact capillary refill. Superficial partial-thickness burns heal in 14 to 21 days, scarring is usually minimal, and there is full return of function.

Deep partial-thickness burns extend into the deep (reticular layer) of the dermis. There is damage to hair follicles as well as sweat and sebaceous glands, but their deeper portions usually survive. Hot liquids, steam, grease, or flame usually cause deep partial-thickness burns. The skin may be blistered and the exposed dermis is pale white to yellow in color. The burned area does not blanch; it has absent capillary refill and absent pain sensation. Deep partial-thickness burns may be difficult to distinguish from full-thickness burns. Healing takes 3 weeks to 2 months. Scarring is common; it is related to the depth of the dermal injury. Surgical debridement and skin grafting may be necessary to obtain maximum function.

Third-degree or full-thickness burns involve the entire thickness of the skin. All epidermal and dermal structures are destroyed. Full-thickness burns are usually caused by flame, hot oil, steam, or contact with hot objects. The skin is charred, pale, painless, and leathery. These injuries will not heal spontaneously, as all dermal elements are destroyed. Surgical repair and skin grafting are necessary, and there will be significant scarring.

Fourth-degree burns are those that extend through the skin to the subcutaneous fat, muscle, and even bone. These are devastating, life-threatening injuries. Amputation or extensive reconstruction is sometimes required.

SPECIFIC ISSUES

Introduction

The American Burn Association has devised a classification of burns, dividing them into major, moderate, and minor, along with indications for referral to a burn unit (Table 199-1).[5,9] Children younger than 10 years of age and adults above age 50 are considered high-risk patients. Patients with underlying medical illnesses such as heart disease, diabetes, or chronic pulmonary problems are considered poor-risk.

Major Burns

Major burns are defined as 1) partial-thickness burns greater than 25 percent BSA in the 10- to 50-year-old age group; 2) partial-thickness burns greater than 20 percent BSA in children under 10 or adults over 50; 3) full-thickness burns of greater than 10 percent BSA in anyone; 4) burns involving the hands, face, feet, or perineum; 5) burns crossing major joints; 6) circumferential burns of an extremity; 7) burns complicated by inhalation injury; 8) electrical burns; 9) burns complicated by fractures or other trauma; 10) burns in infants and the elderly; and 11) burns in poor-risk patients. These burns typically require referral to a specialized burn treatment center.

Moderate Burns

Moderate burns are 1) partial-thickness burns of 15 to 25 percent BSA in the 10- to 50-year-old age group; 2) partial-thickness burns of 10 to 20 percent BSA in children under 10 or adults over 50; and 3) full-thickness burns of less than 10 percent BSA in anyone. Partial-thickness burns of the hands, face, feet, or perineum or circumferential burns of an extremity are excluded. These patients typically require hospitalization for burn care.

Minor Burns

Minor burns include 1) partial-thickness burns of less than 15 percent BSA in the 10- to 50-year-old age group; 2) partial-thickness burns of less than 10 percent BSA in children under 10 or adults over 50; and 3) full-thickness burns of less than 2 percent BSA in anyone, without associated injuries. These burns generally require only outpatient treatment.

Inhalation Injury

With improvements in the treatment of burn shock and sepsis, inhalation injury has emerged as the main cause of mortality in the burn patient.[2,3,6] Despite advances in respiratory support, smoke inhalation injury significantly increases mortality; half of all fire-related deaths are due to smoke inhalation. Inhalation injuries are associated with closed-space fires and conditions that decrease mentation—such as overdose, alcohol intoxication, drug abuse, and head injury. Exposure to smoke includes exposure to heat, particulate matter, and toxic gases.[10]

There is general consensus that direct thermal injury is limited to the upper airway. Thermal injuries below the vocal cords occur only in cases of steam inhalation.

Smoke contains particulate matter, usually less than 0.5 um in size, which is formed from incomplete combustion of organic material. Small particles may reach the terminal bronchioles, where they can initiate an inflammatory reaction, leading to bronchospasm and edema.

Toxic inhalants are divided into three large groups: tissue asphyxiants, pulmonary irritants, and systemic toxins.[10] The two major tissue asphyxiants are carbon monoxide and hydrogen cyanide.

Carbon monoxide poisoning is a well-known consequence of smoke inhalation injury. Severe carbon monoxide poisoning will produce brain hypoxia and coma. Comatose patients lose airway protective mechanisms, which may result in aspiration, thus further exacerbating the pulmonary injury from smoke inhalation. All patients with suspected carbon monoxide exposure should be started on 100% oxygen by non-rebreather mask and be evaluated for hyperbaric oxygen therapy (see Chap. 203).

Hydrogen cyanide is formed when nitrogen-containing polymers—such as wool, silk, polyurethane, or vinyl—are burned. Cyanide binds to and disrupts mitochondrial oxidative phosphorylation, leading to profound tissue hypoxia. Specific treatment for cyanide toxicity may be required (see Chap. 188).

Inhalation injury damages endothelial cells, produces mucosal edema of the small airways, and decreases alveolar surfactant activity, leading to bronchospasm, airflow obstruction, and atelectasis. With time, tracheal and bronchial epithelial sloughing occurs. As these patients are resuscitated with large quantities of fluid for their burn injury, pulmonary edema develops. Approximately half of intubated burn patients admitted to burn centers develop acute respiratory distress syndrome (ARDS).[11] Therefore, when inhalation injury is present, fluid resuscitation should be done carefully to avoid exacerbating pulmonary edema, and early institution of hemodynamic monitoring is recommended.

Bronchospasm may occur early, but lower airway edema is usually not clinically evident for up to 24 h. Upper airway edema, however, can occur rapidly. Although the injury is mainly to the airways, pulmonary vascular changes do occur. There is no single method capable of demonstrating the extent of inhalation injury. Diagnosis of smoke inhalation is made from the history of a fire in an enclosed space and physical signs that include facial burns, singed nasal hair, soot in the mouth or nose, hoarseness, carbonaceous sputum, and expiratory wheezing. Carboxyhemoglobin levels are useful to document prolonged exposure within an enclosed space with incomplete combustion. The chest radiograph may be normal initially; bronchoscopy and radionuclide scanning are useful in determining the full extent of injury.

Treatment of suspected inhalation injury should be instituted prior to definitive diagnosis. Humidified oxygen (100 percent) should be administered by mask. Arterial blood gases including carboxyhemoglobin levels should be obtained. In suspected cases, control of the upper airway is achieved by prompt endotracheal intubation. Indications for intubation include 1) full-thickness burns of the face or perioral region, 2) circumferential neck burns, 3) acute respiratory distress, 4) progressive hoarseness or air hunger, 5) respiratory depression or altered mental status, and 6) supraglottic edema and inflammation on bronchoscopy.

TREATMENT

Introduction

The management of patients with *moderate to major* burns can be divided into three phases: 1) prehospital care, 2) ED resuscitation and stabilization, and 3) admission or transfer to a specialized burn center.

Prehospital Care

The following principles are the basis of prehospital care for burn patients: 1) stop the burning process, 2) establish the airway, 3) initiate fluid resuscitation, 4) relieve pain, 5) protect the burn wound, and 6) transport the patient to an appropriate facility.

On-site assessment of a burned patient is divided into primary and secondary surveys. In the primary survey, immediate life-threatening conditions are quickly identified and treated. Initial management of the burned patient should be the same as for any other trauma patient, with emphasis on airway, breathing, circulation, and cervical spine immobilization. During the secondary survey, a thorough head-to-toe evaluation is carried out.

The patient must be removed from the burning process and burning clothing must be immediately removed and the remainder of the clothing removed after the airway, breathing, and circulation (ABCs) are secured. All rings, watches, jewelry, and belts should be removed, as they can retain heat and produce a tourniquet-like effect on the extremity, causing ischemia. A 100 percent oxygen mask should be applied. Thought should be given to an airway that has the potential to swell rapidly, even though initial assessment may be acceptable. Prophylactic intubation should be considered in burns about the face sustained in a closed-space fire. Intravenous fluids are started with isotonic crystalloid, usually LR solution. The patient should be covered with clean sheets to protect the wound. Early cooling can reduce the depth of burn and reduce pain, but uncontrolled cooling will result in hypothermia. Analgesia can be given upon direction of the on-line medical control physician. The patient should be transported to the nearest hospital capable of caring for a burn patient or, if none is available, the nearest hospital for stabilization.

Emergency Department Management

Upon arrival at the ED, a directed history should be obtained from the patient and emergency medical services (EMS) personnel. What was the burning agent? Were chemicals involved? What was the duration of exposure? Was the fire in an open or enclosed space? If the fire was in an enclosed area, what substances were burned? Was there an explosion causing the patient to suffer a blast injury? Was there any contact with electricity? Was there any other trauma or loss of consciousness? A general history including past medical and surgical illnesses, chronic disease, allergies, medications, and tetanus immunization status should be obtained from the patient or family.

The patient's respiratory and circulatory status should be reassessed and stabilized. The adequacy of or need for cervical immobilization should also be reassessed. The patient should be examined for signs of inhalation injury, evidenced by facial burn, carbonaceous sputum, singed nasal hair, and soot in the mouth. If there is any evidence of airway compromise with swelling of the neck, burns inside the mouth, or wheezing, endotracheal intubation should be performed.

The adequacy of circulation is initially assessed by the blood pressure, pulse rate, capillary refill time, mental status, and urinary output. When possible, intravenous lines should be inserted in nonburned areas, but when this is not possible, a burned area can be used and resuscitation started according to the burn fluid-resuscitation formula.

During the secondary examination, a head-to-toe assessment, including an eye examination for corneal burns, should be done. The size of the burn and its depth should be estimated and recorded. Patients with a greater than 20 percent partial-thickness burn routinely require a nasogastric tube, as ileus frequently occurs. A urinary drainage catheter should be inserted to measure urinary output and prevent urinary retention in patients with perineal burns.

Routine laboratory tests including a complete blood count (CBC), electrolytes, blood urea nitrogen (BUN), creatinine, and glucose should be obtained. In patients with suspected inhalation injury, arterial blood gases, carboxyhemoglobin level, chest radiograph, and electrocardiogram (ECG) should be obtained. Fiberoptic bronchoscopy is indicated when there is a suspicion of inhalation injury and in intubated patients, as this is both diagnostic and therapeutic in clearing the airways. A urinalysis for myoglobin and creatine kinase (CK) levels should be done, along with an ECG in patients with electrical injury to assess muscle or cardiac injury. Additional radiographs should be taken as indicated for other suspected trauma.

The burn shock resuscitation formulas in use today are derived from laboratory studies of burn shock and resuscitation. The value of these formulas has been questioned.[12] In general, it appears that the traditional approach using crystalloid may underestimate fluid requirements when compared to resuscitation guided by cardiorespiratory monitoring. The value of early fluid resuscitation is supported by clinical experience.[12,13] However, no consensus exists on the appropriate assessment of resuscitation and its effect on outcome.[12] At this time, the formulas only provide a *guide* for fluid resuscitation that must be monitored and adjusted according to patient response.

The Baxter or Parkland formula is probably the most widely used thermal injury resuscitation regimen in North America.[4,5] This formula calls for 4 mL of LR solution multiplied by the percentage of BSA burned (second- and third-degree burns only) multiplied by the body weight in kilograms. Half of this total is given in the first 8 h after injury and the rest during the next 16 h (Table 199-2). The amounts may be large, and hemodynamic monitoring techniques are now commonly used to protect against inadvertent volume overload.

Electrical injuries, incineration burns, and associated crush injuries may produce rhabdomyolysis and myoglobinuria, leading to renal failure. Acute renal failure occurs in approximately 15 percent of patients admitted to burn centers and is associated with severe burns (mean BSA involvement 48 percent).[14] Therapy may be required to limit renal damage from myoglobinuria (see Chap. 279).

Thermal injury in the presence of concomitant multisystem trauma generally requires fluids in excess of calculated needs. Inhalation injuries have been shown to increase total fluid needs. Burn patients with preexisting cardiac or pulmonary disease require much greater attention to fluid management. Fluid resuscitation should be monitored closely by frequent assessment of the patient's vital signs, signs of cerebral and skin perfusion, and urinary output as well as hemodynamic monitoring. The urinary output should be 0.5 to 1.0 mL/kg per h.

There are several methods of calculating fluid resuscitation for infants and children. One method is to use the Parkland formula and modify it to maintain urinary output of 1 mL/kg per h. Alternatively, a pediatric maintenance rate for 24 h can be calculated plus an additional 2 to 4 mL/kg multiplied by percentage of BSA burned, with the entire amount infused over the first 24 h. In children weighing less than 25 kg, a urine output of 1.0 mL/kg per h is necessary.

It is possible for patients with major burns to receive excessive intravenous fluids during the prehospital and ED phases, particularly if two large-bore peripheral catheters are in place with fluid infusing wide open. Total fluids infused should be documented and titrated to the patient's response.

Two additions or modifications to isotonic crystalloid resuscitation have been studied: adjuvant colloid and hypertonic saline. However, neither improves patient outcome. Adjuvant colloid given along with isotonic crystalloid resuscitation has not proven beneficial and is associated with increased accumulation of water in the lungs and decreased glomerular filtration rate.[15] Hypertonic saline has produced an increased rate of renal failure and death.[16]

Routine tetanus toxoid prophylaxis should be administered based on the patient's immunization history. Tetanus immune globulin should be administered in patients without a history of full primary immunization. The use of systemic prophylactic antibiotics is inappropriate.

Treatment of inhalation injury includes humidified oxygen, intubation and ventilation, bronchodilators, pulmonary toilet, and hyperbaric oxygen for severe carbon monoxide poisoning.

Burns to a pregnant patient are associated with significant morbidity to mother and child. The outcome of the pregnancy is determined by the extent of the mother's injury; spontaneous termination of pregnancy is the common outcome in large-BSA burns. Fluid requirements may exceed those estimated using the formula. Fetal monitoring and early consultation with the obstetrician is recommended.

Wound Care

After evaluation and resuscitation, the burn wounds are addressed.[17] Initially in the ED, the wound is best covered with a clean, dry sheet. Later, small burns can be covered with a moist saline-soaked dressing while the patient is awaiting admission or transfer. The soothing effect of cooling on burns is most likely due to local vasoconstriction. Studies have shown that cooling stabilizes mast cells and reduces histamine release, kinin formation, and thromboxane B_2 production. In large burns, sterile drapes are better, as saline-soaked dressings applied to a large area can cause hypothermia. The admitting service should be consulted early. The use of antiseptic dressing should be avoided in the ED as the admitting service will need to assess the wound. If the patient is going to be transferred, the accepting burn unit should be contacted for specific instructions regarding burn care. Do not delay transfer for debridement of the wound. The transferring facility should utilize the regional burn center's treatment protocol.

Patients with circumferential deep burns of the limbs may develop compromise of the distal circulation. Distal pulses need to be monitored closely; a Doppler flow probe may be very helpful. If there is compromise to the circulation, escharotomy will be needed. The eschar needs to be incised on the midlateral side of the limb, allowing the fat to bulge through. This may be extended to the hand and fingers (Figure 199-3). Escharotomy may provoke substantial soft tissue bleeding.

If there are circumferential burns of the chest and neck, the eschar may cause mechanical restriction to ventilation. An escharotomy of the chest wall needs to be done to allow adequate ventilation. Incisions need to be made at the anterior axillary line from the level of the second rib to the level of the twelfth rib. These two incisions should be joined transversely so the chest wall can expand (Figure 199-4).

FIGURE 199-3. Escharotomy of the hand.

FIGURE 199-4. Escharotomy of the chest wall.

Pain Control

All burns are painful, and superficial partial-thickness burns are the most painful. Burn injury not only makes an injured area and surrounding tissue more painful, but also causes hyperalgesia, chiefly due to the A fibers. Local cooling may be soothing, but does not provide pain control.[18] Therefore pain management should be provided.

During the emergency phase, the preferred route for most medication is intravenous, because of the potential problems with absorption from the muscle and gastrointestinal tract related to decreased perfusion. Morphine is the most widely used drug for relief of pain, and relatively large doses may be required. Anxiolytic agents should be used as adjuvants in pain management.

During the acute phase and for ambulatory patients treated in the ED, opioid analgesics are required for procedural pain. Oral analgesics such as codeine, hydrocodone, oxycodone, or nonsteroidal anti- inflammatory drugs may be used for the background pain.

CARE OF MINOR BURNS IN THE EMERGENCY DEPARTMENT

The American Burn Association has defined minor burns that can be treated on an outpatient basis. To qualify as a minor burn, the injury should be isolated and not involve hands, face, feet, or perineum. The burn should not cross major joints or be circumferential. In treating a minor burn, the patient's social and medical situation should be considered. For example, an elderly patient or one with medical problems is best treated as an inpatient, even though the burn involves less than 10 percent of the BSA. The patient's reliability should be considered as an important factor for outpatient treatment. Care of minor burns requires coordination between the ED and the referral specialist who will see the patient in follow-up.[17]

As burns are painful, appropriate analgesia is required. After appropriate analgesia, the burn wound is cleaned with mild soap and water or dilute antiseptic solution. Blisters may be left intact or drained, or the overlying epithelium may be debrided; the decision depends on size and location. Large blisters or those over very mobile joints should be debrided. Small blisters on nonmobile areas should be left intact. Where compliance is questionable, patients should have the blisters debrided, because an intact or spontaneously collapsed blister may serve as a focus for wound infection. The patient's tetanus immunization status should be assessed and tetanus toxoid and/or immunoglobulin should be administered as needed.

Topical antimicrobials have an important role in reducing bacterial colonization and enhancing the rate of healing in burns.[4,5] A wide variety of topical agents are commonly used for minor burns. The most common is 1% silver sulfadiazine because it is easy to apply and has relatively little toxicity. The usual practice is to apply a thin layer of silver sulfadiazine cream to the burn and then cover it with gauze dressing. Silver sulfadiazine should not be used in patients with sulfa allergy, or on the face because of potential staining. Alternative opinions about the routine use of silver sulfadiazine have been expressed.[19]

Alternative topical agents to use in these circumstances are bacitracin or triple-antibiotic (neomycin, polymyxin B, and bacitracin zinc) ointments. Although 8.5% mafenide acetate cream and 0.2% furacin ointment are available for topical use, these should be used with caution if applied to large burns in an outpatient setting. Mafenide is a carbonic anhydrase inhibitor and can cause metabolic acidosis. Furacin is in a polyethylene glycol vehicle that can be toxic if absorbed in patients with compromised renal function. Mafenide penetrates the eschar well and has utility in treating patients with invasive infections.

Dressings are ideally changed twice daily as long as the wounds continue to weep; then they are changed daily until the burn is healed. Synthetic occlusive dressing is an alternative method of managing partial-thickness burns in outpatients. The wounds are cleansed and debrided prior to application of these dressings (e.g., Biobrane, Dow Hickam Pharmaceuticals; Tegaderm, 3M Health Care; DuoDERM, Bristol-Myers Squibb). This method is most successful for clean burns on flat surfaces. The goal is to have the dressing adhere to the wound so that it acts as artificial skin. Adherence is important, as most of the bacteria causing infection produce fibrinolytic agents. Wounds are checked at 24 to 48 h for adherence, and the dressing is left in place until spontaneous separation occurs. There is evidence that wounds treated with these synthetic occlusive dressings are better tolerated by patients, require fewer dressing changes, and heal with better appearance.[20]

Patients must be given discharge instructions that explain home burn care and symptoms and signs of infection. The patient should be advised to return to the ED immediately if there are any signs or symptoms of infection. Extremity burns should be elevated for 24 to 48 h to prevent edema. All burn wounds should be reassessed at 24 h for depth and extent of burn. The follow-up visit schedule should be clearly explained and analgesics prescribed. Deep partial-thickness, full-thickness, and mixed-thickness burns should be referred to a plastic surgeon or burn-care specialist in 2 to 4 days for reevaluation and consideration of skin grafting.

REFERENCES

1. American Burn Association: Burn incidence fact sheet. Accessed at http://www.ameriburn.org, January 29, 2003.

2. Ryan CM, Schoenfeld DA, Thorpe WP, et al: Objective estimates of the probability of death from burn injuries. *New Engl J Med* 338:362, 1998.

3. Muller MJ, Pegg SP, Rule MR: Determinants of death following burn injury. *Br J Surg* 88:583, 2001.

4. Sheridan RL: Burns. *Crit Care Med* 30(Suppl):S500, 2002.

5. Saffle J (ed): *Practice Guidelines for Burn Care.* Chicago, American Burn Association, 2001.

6. Saffle JR, Davis B, Williams P, American Burn Association Registry Participant Group: Recent outcomes in the treatment of burn injury in the United States: A report from the American Burn Association Patient Registry. *J Burn Care Rehabil* 16:219, 1995.

7. Baxter CR, Shires T: Physiological response to crystalloid resuscitation of severe burns. *Ann NY Acad Sci* 150:874, 1968.

8. Hendricks WM: The classification of burns. *J Am Acad Dermatol* 22:838, 1998.

9. Guidelines for the Operation of Burn Units, in Committee on Trauma, American College of Surgeons: *Resources for Optimal Care of the Injured Patient.* Chicago, American College of Surgeons, 1999. [Available from the American Burn Association website at http://www.ameriburn.org.]

10. Hartzell GE: Overview of combustion toxicology. *Toxicology* 115:7, 1996.

11. Dancey DR, Hayes J, Gomez M, et al: ARDS in patients with thermal injury. *Intensive Care Med* 25:1231, 1999.

12. Holm C: Resuscitation in shock associated with burns. Tradition or evidence-based medicine? *Resuscitation* 44:157, 2000.

13. Barrow RE, Jeschke MG, Herndon DN: Early fluid resuscitation improves outcomes in severely burned children. *Resuscitation* 45:91, 2000.

14. Holm C, Horbrand F, von Donnersmarck GH, et al: Acute renal failure in severely burned patients. *Burns* 25:171, 1999.

15. Gore DC, Dalton JM, Gehr TW: Colloid infusions reduce glomerular filtration in resuscitated burn victims. *J Trauma* 40:356, 1996.

16. Huang PP, Stucky FS, Dimick AR, et al: Hypertonic sodium resuscitation is associated with renal failure and death. *Ann Surg* 221:543, 1995.

17. Smith S, Duncan M, Mobley J, et al: Emergency room management of minor burn injuries: A quality management evaluation. *J Burn Care Rehabil* 18:76, 1997.

18. Werner MU, Lassen B, Pedersen JL, et al: Local cooling does not prevent hyperalgesia following burn injury in humans. *Pain* 98:297, 2002.

19. Chung JY, Herbert ME: Myth: Silver sulfadiazine is the best treatment for minor burns. *West J Med* 175:205, 2001.

20. Barret JP, Dziewulski P, Ramzy PI, et al: Biobrane versus 1% silver sulfadiazine in second-degree pediatric burns. *Plast Reconstr Surg* 105:62, 2000.

- **Editor:**
  - Judith E. Tintinalli, MD, MS
  - (Co-Editors)
    Gabor D. Kelen, MD
    J. Stephan Stapczynski, MD
- **ISBN:**
  - 0-07-138875-3
- **Publication Year:**
  - 2004
- **Publisher:**
  - McGraw-Hill, Medical Publishing Division
- **Date Posted:**
  - 2/15/2007 9:39:06 AM PST (GMT -08:00)
- **Book Title:**
  - Emergency Medicine: A Comprehensive Study Guide - 6th Ed. (2004)
- **Date Accessed:**
  - 3/5/2007 6:34:06 AM PST (GMT -08:00)
- **Electronic Address:**
  - http://online.statref.com/document.aspx?fxid=80&docid=1276
- **Location In Book:**
  - EMERGENCY MEDICINE: A COMPREHENSIVE STUDY GUIDE - 6th Ed. (2004)
    SECTION 15 - ENVIRONMENTAL INJURIES
    199. THERMAL BURNS - Lawrence R. Schwartz, Chenicheri Balakrishnan
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